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Clinical and Research Protocol for Osteopathic Manipulative Treatment of Elderly Patients With Pneumonia

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Pneumonia in elderly patients is a major public health concern because of greater morbidity and mortality and longer hospital stays relative to younger populations. Based on the premise that osteopathic manipulative treatment (OMT) is beneficial in the management of pulmonary infections, the Multicenter Osteopathic Pneumonia Study in the Elderly (MOPSE) was designed as a prospective randomized controlled trial to evaluate the efficacy of OMT as an adjunct to the current pharmacologic treatment of elderly patients hospitalized for pneumonia. The protocol developed for MOPSE has its origins in early osteopathic medical literature at a time when effective antibiotic therapy was unavailable and osteopathic physicians relied on physical examination and empiric reasoning to develop treatment strategies and OMT techniques to improve host defenses against pneumonia. The present paper reviews the early osteopathic medical literature to identify the reasoning behind the OMT techniques that are the basis for the design of the MOPSE protocol. Likewise, the contemporary medical literature relevant to the protocol is reviewed. Finally, a description of the study design and the OMT and light touch (sham) protocols used in MOPSE are provided.

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Osteopathic manipulative treatment (OMT) originated in the late 19th century at a time when infectious diseases were the leading cause of death.¹ In 1864, after three of his children died from infectious spinal meningitis, Andrew Taylor Still, MD, DO, became determined to find alternative approaches to medical care. This search led to his discovery of osteopathic medicine in 1874.² By the early 20th century, both osteopathic and allopathic medical schools had widely accepted the germ theory of disease.³ However, while allopathic physicians searched for pharmaceutical agents to treat specific pathogens, osteopathic physicians developed manual techniques and strategies intended to treat infections by improving host defenses.³

Before the widespread availability of effective antibiotics, a rich body of literature was published on the use of OMT for lower respiratory tract infections such as influenza and pneumonia. Although authors debated details of anatomy, mechanisms of action, useful manipulation techniques, technique combinations, and the most effective frequency and duration of treatment sessions, certain theories were common. Yet the evidence supporting this literature is anecdotal. As a result, two major questions remain:

- Is OMT beneficial for patients with pneumonia?
- Does OMT have a role as an adjunctive treatment to modern antibiotic therapy?

To answer these questions, the Multicenter Osteopathic Pneumonia Study in the Elderly (MOPSE) was conducted.

As a registered, five-site, hospital-based, prospective randomized controlled trial (ClinicalTrials.gov number NCT00258661), MOPSE was designed to evaluate the efficacy of OMT as an adjunctive treatment to conventional medical care for elderly patients hospitalized for pneumonia. Elderly patients were targeted for this study because in the past decade, two smaller, single-site clinical trials yielded promising results in this population.^{4,5}

The OMT protocol used in MOPSE has its origins in the osteopathic medical literature of the early 1900s. The protocol incorporates eight standardized OMT techniques yet allows for nonstandardized treatment to address somatic dysfunction unique to each patient. While familiar to osteopathic physicians, the techniques are not well known to the larger biomedical community. Space limitations in most peer-reviewed med-

ical journals preclude a detailed description of the MOPSE techniques or their development and rationale. Thus, the purpose of the present paper is to describe the historical development and rationale for OMT in the management of pneumonia, to review the modern supportive literature, and to outline the MOPSE protocol and study design.

Historical Literature Review

Limited by the lack of objective instrumentation, osteopathic physicians in the early 20th century relied on physical examinations to evaluate their patients. Through repeated observations, they correlated visceral diseases with abnormal structural findings, now known as somatic dysfunctions, which primarily consisted of positional asymmetry of bony landmarks, restricted joint motion, tissue congestion, muscle tightness, and palpatory tenderness. Dysfunctions of the thoracic spine, particularly from T1 to T10, and the associated ribs routinely corresponded with lower respiratory tract infections.^{6,7} Experimental observations from animal studies in the early 20th century supported these findings.^{6,7} Correlation was noted between somatic dysfunction from C7 to T3 and congestion of the upper lobes of the lungs.^{6,7} Dysfunction from T5 to T8 correlated with overall congestion of the lungs.^{6,9} Associations between pneumonia and somatic dysfunction were also noted in the cervical region and the cervicothoracic junction (thoracic inlet), which included the first ribs and clavicles.⁶⁻⁹

Osteopathic physicians observed that these musculoskeletal system findings seemed to correspond to patients who had higher incidences of morbidity and mortality. Therefore, somatic dysfunction was hypothesized to impede the body's ability to recover from influenza and pneumonia^{10,11} through any of the following three interdependent processes:

- mechanically impairing rib cage and diaphragmatic motion
- distorting the transmission of neurologic impulses through autonomically regulated reflexes
- impairing circulation, particularly at the venous and lymphatic levels

Early osteopathic physicians associated rib cage dysfunction with pulmonary disease by each of these three observed mechanisms. From the mechanical perspective, tight muscles and restricted joints of the rib cage were observed to limit rib and thoracoabdominal diaphragm motion, limiting lung aeration and promoting congestion.¹²⁻¹⁵ From a neurologic and circulatory view, thoracic paraspinal tissue tightness and restricted vertebral motion were believed to cause venous congestion in and around the sympathetic chain ganglia, causing aberrant sympathetic somatovisceral reflexes. This congestion was thought to alter resting membrane potentials of nerve bodies within the ganglia, causing aberrant sympathetic reflexes or a hypersympathetic tone resulting in vasoconstriction and congestion within the lung parenchyma, a process described as altered somatovisceral reflexes. In addition,

early 20th century osteopathic physicians cited the need to treat the lower thoracic and upper lumbar spine to relieve thoracic tissue tightness around the nerves that innervate the liver and kidneys. They thought this would improve the removal of circulatory waste products that originate from the pneumonic process.¹²⁻¹⁵

In the 1940s and 1950s, researchers in the osteopathic medical profession focused on spinal reflexes in an effort to validate many of these hypothetical mechanisms.¹⁶⁻²⁰ However, their work fell short of establishing the existence of viscerosomatic reflexes in pneumonia or the ability to therapeutically modulate them through manipulative techniques.¹⁶⁻²⁰

Another potential association of rib cage somatic dysfunction in pneumonia is considered a consequence of both biomechanical and neurologic factors. Abnormal tissue tightness, asymmetry of skeletal structures, or restricted joint motion associated with somatic dysfunction in the thoracic cage could reduce, by direct impingement, capillary and lymphatic drainage through structures such as the intercostal lymph vessels, the bronchomediastinal lymphatic trunk, and thoracic ducts.²¹ In addition, changes at the sympathetic chain ganglia could also cause hypersympathetic tone, resulting in vasoconstriction within the pulmonary vasculature and a greater decrease in venous flow. By any mechanism, such impediments were thought to reduce the efficacy of the immune response.

Dysfunction in the cervical region, particularly at the base of the skull and the first two vertebral levels, also seemed to correlate with pneumonia. Osteopathic physicians hypothesized that somatic dysfunction in this region would irritate the vagus nerve, altering parasympathetic tone to the pulmonary system and resulting in changes in glandular secretion and vasomotor control.^{11-13,22-26} Dysfunctions at other cervical levels were thought to influence the phrenic nerve, potentially affecting diaphragmatic motion.¹² Cervical fascia could obstruct lymphatic drainage of the lungs, particularly at the outlet of the thoracic duct.^{27,28} Because sympathetic innervation to the pulmonary vascular and lymphatic vessels is contiguous to the cervical sympathetic ganglia, cervical somatic dysfunction was suggested to influence thoracic and right lymphatic duct flow through alterations in sympathetic nerve transmission.²⁹

Based on these findings, a basic and overall diagnostic and therapeutic framework for the use of OMT in patients with pneumonia is summarized in *Figure 1*.^{10,12-15,30-34}

Origins of OMT Techniques

When developing the treatment protocol used in MOPSE, case reports and articles from early 20th century osteopathic medical literature were reviewed, along with the rationale developed by early osteopathic physicians. In treating patients with pneumonia, OMT was designed to augment host defenses and was not intended to be pathogen-specific.³⁵⁻³⁸ Techniques for managing pneumonia were generally the same as those used for influenza.³⁹ The importance of giving gentle and

Commonly Described Findings	Treatment Considerations
<ul style="list-style-type: none"> ■ Cervical Region* □ Occipital lesions □ Upper cervical spine □ Contracted accessory muscles of respiration ■ Thoracic Region* □ Clavicles □ Rib lesions and rigid intercostal muscles □ Thoracic lesions □ Upper thoracic spine <ul style="list-style-type: none"> – T1-T5^{74,75} – T1-T7²⁰ – T1-T8¹⁷ – T2-T7¹⁸ – T2-T8¹⁹ – T10-L2⁷⁵ – T11-T12¹⁸ □ Rigid muscles in upper thoracic spine □ Rigid muscles in T10-T12 region □ Rigid diaphragm ■ Others* □ Lymphatic congestion^{10,35,76} □ Lumbosacral lesion^{25,77} 	<ul style="list-style-type: none"> ■ Techniques Directed to a Specific Area □ Soft tissue and paraspinal inhibition <ul style="list-style-type: none"> – Areas of segmental somatic dysfunction – Areas exerting a specific influence on visceral or circulatory functions such as the osteopathic centers □ Specific high-velocity thrust techniques[†] □ Long-lever articulatory techniques ■ Areas Commonly Treated □ Cervical spine <ul style="list-style-type: none"> – Influence vagus, phrenic, and recurrent laryngeal nerve for visceral and respiratory function – Reduce fever, headaches, nausea □ Thoracic spine <ul style="list-style-type: none"> – Reduce pulmonary congestion and sustain heart action – Aid circulation through liver and spleen – Aid elimination of toxins through kidneys ■ Nonspecific Physiologic and Homeostatic Maneuvers[‡] □ Release the anterior cervical soft tissues □ Raise the clavicles □ Release the diaphragm □ Lymphatic thoracic pump (and variations) □ Splenic pump □ Ventral techniques <ul style="list-style-type: none"> – Pumping of the liver – Manipulating the kidneys

Figure 1. Summary of the findings and treatment considerations in patients with pneumonia from 1901 to 1951. The therapeutic goals were to (1) influence somatovisceral and viscerosomatic activity, (2) improve respiratory and circulatory dynamics, and (3) enhance immunocompetence. *Numerous findings were roughly attributed to a region and were not segment-specific. †Specific high-velocity thrust techniques were often considered to exert strong influence on the somatovisceral and viscerosomatic activity. Intensity, dosage, and frequency were often cautioned. ‡Maneuvers consisted of a variety of techniques thought to specifically influence the respiratory, circulatory, and eliminatory functions as well as stimulate or boost the body's immune system.

relaxing treatments were emphasized.^{30,37} Nonspecific techniques such as rib raising were applied bilaterally, even when pneumonia was unilateral.³⁰

The optimal duration and frequency of an OMT session was debated. Recommendations varied, but the consensus in the early 1900s was that sessions should not be longer than 15 minutes.^{37,40-42} The typical recommended frequency was two treatment sessions per day, though the seriously ill received more treatment sessions.^{37,42-44} Most serious or acutely ill patients were treated while they were in bed.³⁷ The rationale for these guidelines was to maximize the treatment effect while avoiding exhaustion or overtreatment of the patient.⁴²

The MOPSE protocol incorporates eight OMT techniques that were commonly used in the management of pneumonia between 1890 and 1950. The protocol incorporates two myofascial release techniques—procedures in which osteopathic physicians feel for a point of balance to achieve a release or relaxation of soft tissues, as described later in this section. Although the term *myofascial release* is relatively new, three articles were found discussing treatments that incorporated myofascial release techniques during the 1918-1919 influenza pandemic.^{41,45,46}

Rib raising is perhaps the oldest and most commonly

described OMT technique for the management of respiratory infections.^{29,40,41,43,47-49} Although Barber⁵⁰ first described rib raising in 1896 as a technique for treating patients with pneumonia, its origin has been attributed to Still, who demonstrated versions of the technique in patients in the sitting, supine, and standing positions.^{51,52} Rib raising was used to improve the mechanical motion of the rib cage, as well as to beneficially modulate the sympathetic nervous system.

Treatment of the diaphragm dates back to Still.⁵³⁻⁵⁵ The term *doming the diaphragm* was first used in 1920 to describe a manipulative method of treating patients for infections of the bronchi and lungs by improving function of the respiratory diaphragm.⁵⁶ This technique was described again in 1923 for managing pneumonia.⁵⁷ Improving diaphragmatic function was thought to not only improve respiratory function but also to influence the drainage of blood and lymphatic vessels and improve pressure gradients in the thorax.^{57,58}

Most early descriptions of managing pneumonia included treatment of patients' cervical spine, particularly the upper cervical spine. In early osteopathic medical literature,^{24,29,59} using the soft tissue technique on the cervical spine was thought to improve parasympathetic and sympathetic tone as well as improve lymphatic drainage of the pulmonary system.

The MOPSE protocol also uses a myofascial technique to loosen up the tissues in the thoracic inlet. Treating the thoracic inlet for respiratory infections was first described by Hazzard²⁹ in 1898, when he wrote, "A tightening of the tissues in these parts may cause a stoppage of the thoracic duct or of the right lymphatic duct." The goal of the myofascial release to the thoracic inlet is to correct any soft tissue restrictions that may impair lymphatic drainage.

Before 1920, the focus of using OMT to improve lymphatic drainage was to influence the autonomic nervous system.^{24,59,60} It was hypothesized that improved lymphatic drainage enhanced the presentation of antigens to the immune system and, therefore, stimulated antibody response to infection. In 1923, Miller⁶¹ described rhythmic depression and pulling on the axillae, which he named the *lymphatic pump*. In 1927, he published an article¹⁰ titled "The Specific Cure of Pneumonia," in which he described a new technique he termed the *thoracic pump*. Other versions became popular and were commonly used in the management of pneumonia.^{12,37,43,44} The version employed in the MOPSE protocol uses a quick release of the hands from the chest wall that was first described by Morey⁶² in 1935.

The MOPSE protocol also uses a lymphatic pump technique called the *pedal lymphatic pump* or the *Dalrymple pump*. Its historical origins remain obscure. The technique was probably developed by Dalrymple, a 1929 graduate of what is now the Des Moines (Iowa) University—College of Osteopathic Medicine.⁶³ Lymphatic pump techniques were thought to enhance lymph circulation, thus relieving congestion at the site of infection, increasing the absorption of antigens, and boosting antibody response infection.^{10,61,62}

Clinical Trials and Current Literature

Only a few clinical trials have attempted to evaluate the efficacy of OMT for treating patients with pneumonia. The first attempt was performed in the 1930s by Watson and Percival,⁴⁹ who collected data on 150 children hospitalized with bronchopneumonia. The children were assigned to receive either a standardized OMT protocol with supportive care or supportive care only.⁴⁹ Neither of these groups received serum treatment, which was an inoculated animal serum used for passive immunization.⁶⁴ A third group of 89 children with lobar pneumonia was assigned to receive serum treatment plus supportive care.

The standardized OMT protocol included soft tissue treatment to the cervical spine, paraspinal muscle inhibition, light stroking to the lower intercostal spaces (a lymphatic technique), rib raising, and intermittent pressure to the suboccipital area. This protocol was given every 2 hours to those children with fevers higher than 103°F and every 3 to 4 hours for those with fevers lower than 103°F. The investigators reported that the "interns and sub-interns" had difficulty treating the subjects as frequently as the protocol required.⁴⁹ Unfortunately, the results of the outcome measures for the manipulative

and nonmanipulative groups were never reported because the investigators believed that "too few cases had been accumulated to be conclusive."⁴⁹

In the early 1960s, Kline⁴⁷ studied 252 children hospitalized for various respiratory tract infections. Subjects were randomly assigned to an OMT group, an antibiotic therapy group, or a combined OMT plus antibiotic group. Supportive therapy was provided to all subjects. The OMT protocol consisted of applying the rib raising technique at varying times and durations according to each patient's age. The mean hospital stay was 6.3 days for the OMT group, 5.8 days for the antibiotic group, and 4.8 days for the combined OMT and antibiotic group.⁴⁷

Noll and colleagues⁴ conducted a pilot study testing the efficacy of OMT in elderly patients hospitalized with pneumonia, with promising results. A second, larger, and more refined single-site study was later conducted using a treatment protocol that became the prototype for MOPSE.⁵ This protocol included rib raising, doming the diaphragm, soft tissue technique to the thoracic and cervical regions, treatment of the thoracic inlet, and the thoracic and pedal lymphatic pump techniques. These OMT techniques were selected because they were commonly used in the early osteopathic medical literature. The twice-daily frequency and 15-minute maximum duration were likewise chosen to reflect common practice standards from that period.

In the study,⁵ 58 elderly patients hospitalized for pneumonia were randomly assigned to an OMT group (n=28) or to a light touch group (n=30). Treatment sessions were conducted twice daily for a maximum duration of 15 minutes, and treatments were administered by second-year osteopathic medical students trained in the protocol. An osteopathic physician specializing in OMT provided at least one non-standardized treatment session during the hospital stay to address specific somatic dysfunction unique to the patient. The mean length of hospital stay was 6.6 days for the OMT group and 8.6 days for the light touch group, a statistically significant 2-day difference. The duration of intravenous and total antibiotic use was similarly reduced by 2 days in the OMT group. Mean body temperatures were higher and white blood counts decreased more slowly in the OMT group.⁵

Some studies published in the past decade have explored the possible therapeutic mechanisms espoused by early osteopathic physicians who revealed that OMT might alter autonomic function, but researchers found a limited connection to pneumonia.

Slow circular kneading of the cervical spine for 2 minutes has been shown to reduce sympathetic tone in the peripheral digits.⁶⁵ Respiratory rate, heart rate, and blood pressure have been reported to increase following cervical mobilization technique. The investigators attributed these increases to elicited changes in sympathetic nervous system activity.⁶⁶

The lymphatic pump concept, meanwhile, has been tested in animal studies. In one study,⁶⁷ manually applied, intermit-

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tent, pulsating pressure to the ventral thorax in rats increased lymph absorption at a distal site. In one canine study,⁶⁸ both thoracic and abdominal pumping increased lymphatic flow in the thoracic lymphatic duct. In a second canine model,⁶⁹ an abdominal lymphatic pump technique resulted in a 23-fold increase in the number of lymphocytes found in lymph fluid from the thoracic duct during treatment.

Early mobilization, defined as getting patients out of bed and sitting or ambulating for at least 20 minutes during the first 24 hours of hospitalization, has been shown to decrease the length of hospital stay by 1.1 days.⁷⁰ Lateral rotation therapy, in which the bed rotates a patient from side to side, has been shown to reduce the incidence of lower respiratory tract infections in patients who received liver transplants.⁷¹ OMT may counter the effects of immobility, possibly by mobilizing body fluids and stimulating deeper breathing while the patient remains in bed.

MOPSE Protocol

Before initiating the study, institutional review board approval was obtained at each study site, and all participants gave informed consent.

Subject Recruitment

Subjects were recruited from seven community hospitals in five states (Michigan, Missouri, New Jersey, Ohio, and Texas). A list of the participating hospitals is available at www.clinicaltrials.gov under trial number NCT00258661.

Subjects were eligible to participate in the study if they were aged 60 years or older, had a new pulmonary infiltrate consistent with pneumonia, and had at least two clinical findings consistent with acute pneumonia, including new cough, fever, new pulmonary lung sounds on auscultation, or an acute change in mental status. To improve recruitment, 10 months into the study the age requirement was lowered to 50 years or older.

Subjects were excluded if they had a nosocomial pneumonia, lung cancer, metastatic malignancy, uncontrolled metabolic bone disease, bronchiectasis, pulmonary tuberculosis, lung abscess, advanced pulmonary fibrosis, current rib or vertebral fracture, previous pathologic fracture, previous study participation, or respiratory failure.

Outcome Measures

The primary hypothesis of MOPSE is that patients who receive adjunctive OMT will have a reduced length of hospital stay, reduced time to clinical stability, and reduced rate of symptomatic and functional recovery compared with light touch (sham) and conventional care groups. In addition, the duration of antibiotic use; the number of complications, including death and ventilator-dependent respiratory failure; and the duration and severity of fever and leukocytosis are expected to be lower in the OMT group. Patient satisfaction is predicted to be higher in the OMT group.

Randomization

All subjects received conventional care management for pneumonia. Stratified, blocked randomization was used to allocate subjects to one of three treatment groups: OMT, light touch, or conventional care only. For all subjects, the attending physicians directed conventional care. Randomization was stratified on study site with block sizes of 3 or 6. The computer-generated allocations were concealed in sealed envelopes that were opened only after enrollment.

All subjects, data collectors, attending physicians, and healthcare personnel responsible for subject care outside of study treatments were blinded to group assignment. A data collector or research coordinator administered a questionnaire within 24 hours of the patient's discharge from the hospital. Responses were used to evaluate the effectiveness of subject blinding.

Intervention

The OMT and light touch groups were to receive their first protocol session within 24 hours of hospital admission. Both groups received two treatment sessions daily at least 6 hours apart until discharge, cessation of antibiotic therapy for pneumonia, ventilator-dependent respiratory failure, or death.

The MOPSE OMT protocol is intended to be standardized enough for scientific reproducibility but flexible enough to allow for the treatment of an individual's unique structural findings. This approach reflects the current clinical application of OMT. To achieve this balance, the protocol is divided into two components: a standardized OMT component, using eight techniques commonly advocated in the management of pneumonia, and a nonstandardized OMT component, allowing for the treatment of somatic dysfunction unique to an individual. Each session is to be approximately 15 minutes in duration, neither shorter than 13 minutes nor longer than 17 minutes, with approximately 10 minutes for the standardized component and 5 minutes for the nonstandardized component. All of the techniques in the protocol are given with each subject supine in bed. In the presence of orthopnea or dyspnea, the subject's head can be elevated up to 45 degrees.

All subjects in the OMT group receive a structural examination to identify unique somatic dysfunction potentially related to pneumonia. Nonstandardized OMT can be given at any time during the 15-minute treatment period. Muscle energy, counterstrain, indirect myofascial release, cranial, and direct articular techniques can be used for treatment.⁷² High-velocity, low-amplitude techniques⁷² were not allowed because of concern regarding patient tolerance.

The following OMT techniques, which were used in the standardized portion, are from the current osteopathic medical literature^{73,74} and are consistent with the general treatment approaches used during the preantibiotic era. Although the techniques are standardized, the application of each technique is dosed according to each patient's tolerance. A description of several of these techniques has been previously pub-

lished.⁷⁵ In addition, a summary of these techniques and the rationale for their use is provided in *Figure 2*.

■ **Soft tissue**—The operator sits or stands at the side of the bed and applies soft tissue technique (kneading and massage) across the subject's thoracic paraspinal muscles. More attention may be given to areas of muscle tightness or spasm. The oper-

ator may use paraspinal muscle inhibition on these areas, but the entire thoracic paraspinal area is treated. Approximate duration is 1 minute.

■ **Rib raising**—The operator sits or stands at the side of the bed and places his or her hands under the subject's thorax, contacting the patient's rib angles with the pads of the operator's

OMT Technique	Description	Rationale for Use
■ Soft Tissue	<ul style="list-style-type: none"> □ Apply soft tissue massage (kneading) across thoracic paraspinal muscles □ Give more attention to areas of muscle tightness or spasm 	<ul style="list-style-type: none"> □ Relaxes thoracic paraspinal muscles □ Aids breathing □ Increases motion of the rib cage
■ Rib Raising	<ul style="list-style-type: none"> □ With hands under subject's thorax, contact rib angles with pads of fingers □ Traction applied to rib angle with flexed fingers □ Rib angle raised using arm as fulcrum 	<ul style="list-style-type: none"> □ Improves movement of ribs and thoracic cage □ Mechanical stimulation of sympathetic chain ganglia and related structures results in improved sympathetic tone in the lung
■ Doming the Diaphragm (with indirect myofascial technique)	<ul style="list-style-type: none"> □ Place one hand under subject where diaphragmatic muscles attach to lower ribs and vertebrae, place other hand on abdominal epigastric area □ Rotate hands in opposite directions to determine direction of greatest freedom of movement □ Move tissues in direction of greatest freedom to point of balance and until release of tissue tension 	<ul style="list-style-type: none"> □ Improves motion of diaphragm □ Releases connective tissue tension within structures of the thorax
■ Soft Tissue to the Cervical Spine	<ul style="list-style-type: none"> □ Apply soft tissue kneading and massage to cervical paraspinal muscles 	<ul style="list-style-type: none"> □ Relaxes secondary muscles of respiration □ Improves sympathetic and parasympathetic nerve flow through neck musculature
■ Suboccipital Inhibition	<ul style="list-style-type: none"> □ Place tips of fingers on occipital condyles □ Apply outward and cephalad traction to decompress occipital joint 	<ul style="list-style-type: none"> □ Improves parasympathetic function □ Releases restricted tissues around vagus nerves
■ Myofascial Release to the Thoracic Inlet	<ul style="list-style-type: none"> □ Place thumbs posteriorly over transverse processes of first thoracic segment □ Place fingers anteriorly on clavicles and first two ribs □ Determine direction of free movement with passive motion testing □ Maintain either indirect or direct position until release 	<ul style="list-style-type: none"> □ Releases tissue restriction □ Promotes improved lymphatic drainage □ Improves pulmonary function and lymphatic circulation
■ Thoracic Lymphatic Pump With Activation	<ul style="list-style-type: none"> □ Place hands on anterior thoracic wall with thenar eminence over pectoralis muscles just below clavicles □ Spread and angle fingers toward subject's sides □ Rapidly alternate pressure on chest wall during subject exhalation □ Maintain pressure at end of exhalation □ Repeat procedure 2-3 times □ Briskly remove hands on 3rd or 4th inhalation 	<ul style="list-style-type: none"> □ Augments lymphatic fluid circulation □ Prevents or corrects atelectasis □ Improves chest wall compliance
■ Pedal Lymphatic Pump	<ul style="list-style-type: none"> □ Gently and rhythmically dorsiflex feet 	<ul style="list-style-type: none"> □ Affects intrathoracic/abdominal pressure gradients □ Facilitates circulation of lymphatic fluids

Figure 2. Summary of osteopathic manipulative treatment (OMT) techniques applied in the management of pneumonia and the rationale for their use in the Multicenter Osteopathic Pneumonia Study in the Elderly.

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fingers. With his or her fingers flexed, the operator applies lateral traction to the rib angle. While traction is maintained, the operator's wrists remain straight as his or her hands move toward the anterior side of the patient's body, raising the subject's rib angle. The operator's arm is used as a lever and the side of the bed as a fulcrum to produce smooth, steady raising and lowering of the rib cage. This motion is repeated several times. The operator's hands are then moved up the thoracic cage, and the procedure is repeated until all the ribs are treated. Restricted areas are treated more intensely to promote normal motion. The technique is repeated on the other side. Approximate duration is 2 minutes.

■ **Doming the diaphragm (with indirect myofascial technique)**—From the side of the bed, the operator places one hand under the subject at the part where the diaphragmatic muscles attach to the lower ribs and vertebrae and places the other hand on the abdominal epigastric area. The operator's hands are rotated in opposite directions to determine the direction of greatest freedom of movement. Tissues are then moved in the direction of greatest freedom to a point of balance and held there until a release of tissue tension is palpated. Approximate duration is 1 minute.

■ **Soft tissue to the cervical spine**—From the head of the bed, the operator places his or her hands on the subject's cervical paraspinal muscles to apply soft tissue kneading and stretching. Approximate duration is 1 minute.

■ **Suboccipital inhibition**—From the head of the bed, the operator places the tips of his or her fingers on the suboccipital muscles at the base of the subject's head. Steady, gentle outward and cephalad traction is applied to achieve a relaxation of tissue tension. Approximate duration is 1 minute.

■ **Myofascial release to the thoracic inlet**—From the head of the bed, the operator places his or her hands with the thumbs lying over the transverse processes of the first thoracic segment posteriorly and the fingers on the clavicles and first two ribs anteriorly. Passive motion testing is used to determine the direction in which the tissues move most freely. The tissues are maintained in an indirect position (direction of ease) until a release is palpated. If a tissue restriction is still palpated, then the tissues are taken to a direct position (direction of bind) until a release is palpated. Approximate duration is 1 minute.

■ **Thoracic lymphatic pump with activation**—From the head of the bed, the operator places his or her hands on the subject's anterior thoracic wall with the thenar eminence of each hand over the pectoralis muscles just below the clavicles. The operator's fingers are spread and angled toward the sides of the subject's body. The subject is asked to take a deep breath and exhale. During exhalation, the operator applies a rapid alter-

nating pressure at a rate of approximately 120 compressions and relaxations per minute on the chest wall, which induces a rhythmic pumping action. At the end of exhalation, some pressure will be maintained on the chest wall.

This procedure is repeated two or three times. The subject's thoracic wall pressure increases with each successive exhalation, and it is sustained with the subsequent inhalation. On the third or fourth inhalation, during the first one-third of the inhalation, the operator's hands are briskly removed from the chest wall. This movement causes a sudden release of built-up pressure on the chest wall and causes the rib cage to rapidly expand, creating a sudden increase in negative intrathoracic pressure and causing air to rush into the lungs. This cycle is then repeated. Approximate duration is 2 minutes.

■ **Pedal lymphatic pump**—The operator stands at the foot of the bed and gently and rhythmically dorsiflexes the subject's feet, causing the abdominal contents to intermittently push or slosh up against the abdominal diaphragm. In the case of a patient who has a lower limb amputation, the operator places his or her hands on the most distal portion of the lower limb. Approximate duration is 1 minute.

These eight standardized techniques were provided to patients in the OMT group in the order that they appear to provide maximum benefit. By following these steps, the patient is first relaxed. Second, his or her rib cage restrictions are relieved and musculoskeletal factors that could be causing maladaptive sympathetic responses to the pneumonic process are eliminated. Third, the osteopathic physician alleviates musculoskeletal factors that could be causing a patient's maladaptive parasympathetic responses to the pneumonic process. Finally, the patient's circulatory and lymphatic flow is augmented within the lung parenchyma and rib cage.

In contrast to the OMT protocol, the light touch protocol is intended to control for and optimize the placebo response from touch and attention within the OMT protocol. The light touch protocol retains the therapeutic aspects of touch, patient expectation, conditioning, and the physician-patient encounter. Although light touch may have therapeutic value, it is intended to be minimally effective in altering musculoskeletal structure, function, and movement of lymphatic fluids, which are all the proposed underlying mechanisms for OMT's effectiveness.

The duration of the light touch nonstandardized component is 5 minutes, which is consistent with the OMT protocol. During this time, the operator purposefully and carefully auscultates both sides of the subject's neck for carotid bruits, all lung fields, and the heart. The lung fields are also lightly percussed.

The 10 minute standardized light touch component mimics the standardized OMT component protocol, touching generally the same areas treated with OMT for the same duration. The following guidelines were employed during the light

touch treatment to minimize the potential and unintentional effect of touch on the neuromusculoskeletal system:

- Avoid prolonged touch in any one area of the body, moving the hands approximately every 5 seconds to avoid the body responding to mechanical forces from prolonged force.
- Contact sites adjacent to but not directly on sites engaged during the OMT protocol whenever possible, especially avoiding contact with the spine.
- By using fulcrum principles, direct force more into the bed mattress to minimize force applied to the subject.
- Flatten and soften the surface of the treating hands to minimize focal areas of force.

Discussion

From a historical perspective, the management of pneumonia in the osteopathic medical profession was based on the premise that OMT augmented the host response to disease. During the past 100 years, this rationale led osteopathic physicians to treat patients with pneumonia by using OMT to improve the functioning of the musculoskeletal, autonomic, and lymphatic systems. This treatment approach led to the development of the MOPSE protocol.

Current medical management of pneumonia focuses on the eradication of the pathogen with antimicrobial agents¹ and the development of vaccines for prevention.^{76,77} Although advances in antibiotic therapy and vaccination have significantly improved outcomes in the management of pneumonia, there are several reasons to identify adjunctive measures that enhance treatment outcomes. Global population aging is projected to increase throughout the century, an increase that will no doubt lead to many older individuals surviving with chronic illnesses and infirmities.⁷⁸ Consequently, the impact of pneumonia and its increased morbidity and mortality on an aging population will continue to increase. Antibiotic resistance is a growing problem, especially in chronically ill and vulnerable populations such as the elderly.¹ Further, considering the possibility of an influenza pandemic, identifying adjunctive means to treat serious respiratory tract infections is a major healthcare imperative. Anecdotal reports from the early osteopathic medical literature and recent pilot studies suggest OMT's benefits in the treatment of patients with lower respiratory tract infections. The Multicenter Osteopathic Pneumonia Study in the Elderly will provide the most rigorous scientific assessment to date of the efficacy of OMT in the management of pneumonia in older individuals.

Conclusion

The MOPSE manipulation protocol has features that are pertinent for both research and patient care. It consists of well-defined, standardized OMT techniques that can be universally applied to those with pneumonia. The incorporation of nonstandardized techniques allows optimization of patient response to treatment. This flexibility is appropriate because

of the wide range of severity of illness and frailty among elderly patients. A 15-minute, twice-a-day protocol is also an achievable standard for current practice. We expect that MOPSE will identify whether or not OMT provides benefits in this patient population and will help guide the future treatment of elderly patients with lower respiratory infections.

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